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the girders, directly as the amount of deflection into the depth of the metal.

The paper concludes by pointing out the important amount of this resistance, the operation of which has been hitherto unknown, and which in cast iron exceeds the tensile strength of the metal, and shows that comparisons of the strength of different forms of section, based on the existing theory, which assumes the resistance at the outer fibre to be constant and equal to the tensile strength of the metal, must be entirely fallacious.

The paper is accompanied by full details of all the experiments, and the measurements for determining the position of the neutral axis.

II. "On the Metallic and some other Oxides, in relation to Catalytic Phenomena." By the Rev. J. EYRE ASHBY.  
Communicated by the Rev. JOHN BARLOW, F.R.S. Received March 8, 1855.

I purpose to detail some experiments on the metallic (and a few other) oxides, made with a view to ascertain their powers to produce and maintain, catalytically, the combustion of various gases and vapours; and to annex such considerations as appear to be suggested by the facts. By catalysis I understand the operation of one body upon another, under favourable circumstances, whereby the second body is resolved into new chemical combinations, while the first (whatever may happen during the process) remains finally unchanged. This must be taken as not including explosion by percussion, in which the change takes place owing to the external application of dynamic force.

The apparatus for experimenting comprehends a variety of shallow capsules; wire-gauze, of iron, copper, and brass, of different degrees of fineness, cut into discs a little larger than the vessels on which they are to be superimposed; a spirit-lamp with large wick; a pair of pliers, and a few rings of wire to support the gauze, if necessary, while heating it in the spirit flame. The method of procedure is simple: the watch-glass, or capsule, is *nearly* filled with

the liquid whose vapour is to be tried; on a wire-gauze disc is spread the oxide whose powers as a catalyser are to be tested, and this being warmed (more or less) over the lamp, is set down upon the upper rim of the capsule. Sometimes it is necessary to heat a layer of the oxide in the middle of a small combustion-tube, and pass over it the gas, or mixture of gases.

I tried the following substances with pyroxylic spirit (hydrated oxide of methyl) and alcohol separately.

1.  $\text{Co}_2\text{O}_3$  appeared to possess the power in some degree, but perhaps the specimen was in too dense agglomeration, which is not essentially reduced by trituration.

2.  $\text{Co}_2\text{O}_3$  maintained the catalytic combustion very well.

3.  $\text{Ag}_2\text{O}$ , reduced to metallic silver, which shows a strong tendency on gauze, and acts perfectly in the combustion-tube.

4.  $\text{U}_2\text{O}_3$ ,  $\text{HO}$  became, at red heat, anhydrous mixture of  $\text{UO}$  and  $\text{U}_3\text{O}_4$ , showing strong tendency. A very pure specimen catalysed the vapour as it changed from yellow to green, after which it died away. Will not act below  $570^\circ$  (F.).

5.  $\text{Sn}_2\text{O}_3$ ; strong tendency.

6.  $\text{Sn}_2\text{O}_3$ ; slight tendency.

7.  $\text{W}_2\text{O}_3$  apparently produces the effect if placed while glowing, over alcohol, but gradually dies away, as if very slowly cooling.

8.  $\text{Pb}_3\text{O}_4$  changed to  $\text{Pb}_2\text{O}_3$ , and showed a strong tendency, but quickly faded and grew cold.

9.  $\text{Cd}$ ,  $\text{O}$ , placed while very warm over pyroxylic spirit, burst into glow and catalysed, but always died off after the lapse of from half a minute to two or three minutes, and then became incapable.

10.  $\text{Ca}_2\text{O}$  (on the gauze), no effect.

11.  $\text{Si}_2\text{O}_2$  exhibited a tendency.

12. Stourbridge clay; no effect.

13.  $\text{Al}_2\text{O}_3$  appeared to have no effect in maintaining catalytic combustion on the gauze, but when made red-hot and quenched in absolute alcohol, it changed from pure white to a black substance and oxidized a portion of the alcohol. That this is not owing to carbon in the alcohol is evident, because the same change occurs when it is quenched in strong liquid ammonia. I suspect that it is a new oxide of aluminium.

14.  $\text{Ni}_2\text{O}_3$ , formed by heating carbonate of nickel nearly to red-

ness, failed; prepared from the common nitrate, it acted for a short time; reduced as an intensely black velvety substance from the purest nitrate, then warmed but not made red-hot, it glowed and catalysed with alcohol or ether. With pyroxylic spirit, it was left at the end of the operation of a greenish drab, which I suspect to be a mixture of  $\text{Ni}_2\text{O}_3$  with  $\text{Ni.O}$ , although it may be  $\text{Ni}_2\text{O}_3$  changed only in appearance, for when treated with nitric acid no nickel is dissolved.

15.  $\text{MnO}_2$  is changed at red heat into  $\text{Mn}_2\text{O}_3$ , which, with alcohol, ether, and pyroxylic spirit, continues the slow combustion very steadily. A specimen of very pure  $\text{Mn}_2\text{O}_3$  acted extremely well, as did also a portion of "euchrome" (a hydrated sesquioxide of manganese (impure) dug from the estate of Lord Audley), after being heated in the air to drive away the carbonaceous matter with which it was mingled.  $\text{Mn}_2\text{O}_3$  will, if sufficient care be taken, catalyse the moist gas arising from a strong solution of ammonia.

16.  $\text{Fe}_2\text{O}_3$ , when in the state of a light puffy powder, catalyses the vapour of ether, alcohol, and pyroxylic spirit, only requiring to be heated on the gauze before it is laid over the capsule. It is cheap, easily employed, and of invariable action. I have kept up the combustion for several hours on a surface of 120 square inches.

By means of a catalytic lamp in which the liquid employed is continually supplied from a reservoir and maintained at a constant level in the capsule, I have used 7 or 8 square inches continuously during thirty-six hours. This lamp I have occasionally used for laboratory purposes, where a gentle and equable heat was required for several hours.

Pursuing my experiments with the oxides of the metals, heated on wire gauze, I tried as many as I could procure or make, and by a tolerably wide induction I found that the *sesquioxides* have the strongest tendency to produce and maintain the catalytic glow, and do produce it in every case in which they are not decomposed by the amount of heat required to begin the operation.

When hydrated  $\text{Fe}_2\text{O}_3$  is heated and placed over alcohol, its colour is deepened towards black, but not uniformly, and when cold the original colour returns. But if it be made red-hot and quenched in boiling alcohol out of contact with air, it is converted into hydrated  $\text{Fe}_3\text{O}_4$ , and remains permanently a deep black magnetic powder, soluble in acids. A strong solution of ammonia may be substituted

for the alcohol with the same effect, but in this case some of the sesquioxide will remain unaltered and mixed with the black oxide. The alcohol or ammonia is correspondingly changed by oxidation derived from the oxygen which has been released from combination with the iron. If the hydrated  $\text{Fe}_3\text{O}_4$  be heated in contact with air, it immediately (even when it has been kept for many months) becomes  $\text{Fe}_2\text{O}_3$  by oxidation from the atmosphere, but if heated to redness *in vacuo*, it cools unchanged. [Can the black powder of alumina be  $\text{Al}_3\text{O}_4$ , formed in a similar way?] The process of catalysation by  $\text{Fe}_2\text{O}_3$  is thus evident; the heated sesquioxide loses a portion of oxygen to the alcohol and becomes  $\text{Fe}_3\text{O}_4$ , which is instantly reconverted into  $\text{Fe}_2\text{O}_3$  by receiving oxygen from the air, and this alternation is constantly going on in every portion of the glowing mass. It is not a mere *action de présence*, but alternate reduction and oxidation of the sesquioxide, producing a continuous oxidation of the alcohol.

This suggests a consideration apparently adverse to the atomic hypothesis of Dr. Dalton. How can a single compound molecule  $\text{Fe}_2\text{O}_3$  be changed by deoxidation into another compound molecule  $\text{Fe}_3\text{O}_4$ , when, according to theory, there are in it but *two* combining proportions of iron, whereas the resultant contains *three*? and how (by deoxidation) can the resultant molecule contain *four* combining proportions of oxygen when the primary contained only *three*? We can indeed represent to the imagination that *three* molecules of the sesquioxide, acting as if they were one triple molecule, lose *one* combining proportion of oxygen, and are converted into *two* molecules of the black oxide; and conversely, that *two* molecules of the black oxide, acting as if they were *one* double molecule, combine with *one* atom of oxygen, and are converted into *three* atoms of sesquioxide. The only way to account for this, in accordance with the popular atomic theory, seems to be, to assume that the notation for these oxides is incorrect, and that

for  $\text{Fe}_2\text{O}_3$  we should write  $\text{Fe}_6\text{O}_9$ ,  
and for  $\text{Fe}_3\text{O}_4$  we should write  $\text{Fe}_6\text{O}_8$ .

If the current notation be retained, and any law be admitted, in virtue of which three molecules of sesquioxide may suffer reduction as if they were only one molecule, and divide into two molecules of the magnetic oxide, we might conceive a peculiar structure in the

$\text{Fe}_3\text{O}_4$ , with a tendency to separate again into  $\text{FeO}$ ,  $\text{Fe}_2\text{O}_3$ ; that it is really in combination as  $\text{Fe}_3\text{O}_4$ , but ready to yield to slight causes and become  $\text{FeO}$ ,  $\text{Fe}_2\text{O}_3$ . This would explain Mr. Mercer's experiment (quoted by Brande, I. 716, edition 1848) of the chemical union of a mechanical mixture of protoxide and peroxide of iron.

Perhaps the sesquioxides occupy a middle place in the scale of effects. Take the case of iron; we have

$\text{Fe} + \text{O}$ , pyrophorus,—violent oxidation,

$\text{Fe}_2\text{O}_3 + \text{NH}_3 + \text{O}$ , alternate reduction and oxidation,

$\text{FeO}_3 + \text{NH}_3$  (in water), reduction.

To show the last, add ammonia to a solution of  $\text{FeO}_3$ ,  $\text{KO}$ , and  $\text{Fe}_2\text{O}_3$  will be precipitated.

A mixture of ten parts by weight of powdered chlorate of potassa with one part of  $\text{Fe}_2\text{O}_3$  disengages oxygen with extreme facility and great economy of heat as compared with the oxides of copper and manganese; and it is the more convenient because  $n$  grains of the mixture will represent almost exactly  $n$  cubic inches of disengaged oxygen.

A state of mechanical division is not absolutely necessary for the catalysation of some inflammable vapours by  $\text{Fe}_2\text{O}_3$ ; an old nail, entirely transmuted into rust, will perform the operation; and when we consider that in many cases of fermentation, decay and putrefaction, this oxide may be present, divided or aggregated, while heat is evolved, and inflammable gases and vapours are set free, we may hereafter be able to trace some instances of "spontaneous combustion" to the catalytic action of the sesquioxides of iron.

### III. "Ocular Spectres and Structures as Mutual Exponents."

By JAMES JAGO, A.B. Cantab., M.B. Oxon., Physician to the Royal Cornwall Infirmary. Communicated by Professor STOKES, Sec. R.S. Received March 5, 1855.

The present communication is a revised and modified version of a paper bearing the same title, which was read on the 18th of January and 1st of February, and which was, by permission, withdrawn. The chief modification applies to the author's views respecting the struc-